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EVALUATION OF SUGAR-BEET TYPES IN CERTAIN SUGAR-BEET-GROWING DISTRICTS IN THE UNITED STATES[1]

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INTRODUCTION

Approximately 16,000,000 pounds of sugar-beet seed are used annually in the United States for planting the commercial sugar-beet acreage. At the present time, although a large portion of this required amount of seed is being produced in this country, there is a considerable importation of seed from Europe. Considering the wide range of soil, climatic, and cultural conditions in the widely separated districts of the 18 States where the beet-sugar industry is located, the problem of determining the specific types of sugar beets best adapted to those districts is presented. The beet-growing lands range from a few feet above sea level to those more than 1 mile in altitude; the annual precipitation ranges from 10 inches or less in some of the irrigated districts to more than 30 inches in some of the humid ones. As a rule the total number of hours of sunshine during the growing season is much greater in the semiarid than in the humid

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[1] Experimental work was conducted as follows: In the Sacramento delta in California, in cooperation with the California Agricultural Experiment Station; in Minnesota, in cooperation with the Minnesota Agricultural Experiment Station; in Michigan, in cooperation with the Michigan State Agricultural Experiment Station; in southern California and in the Arkansas Valley, Colo., in cooperation with the American Crystal Sugar Co.; in northern Colorado, in cooperation with the Colorado Agricultural Experiment Station; in Idaho, in cooperation with the Amalgamated Sugar Co.; and in Utah and South Dakota, in cooperation with the Utah-Idaho Sugar Co. Acknowledgment is made to G. H. Coons for assistance in the preparation of the manuscript.

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districts, in which humidity is considerably higher as compared with the low humidity under semiarid conditions of the irrigated regions, where the larger portion of the sugar-beet crop is grown. This is in striking contrast to most of the sugar-beet-producing areas in Europe where beets are grown under conditions of natural rainfall and where differences in altitude are much less pronounced. Considering the wide range of conditions encountered, it can readily be seen that the choice of the proper type of sugar beet for a given area is important, since, irrespective of how sound an agricultural practice for a given area may be, it cannot overcome the use of a type of sugar beet unsuited to that area.

Thirty years ago a series of comparative tests (*13*)[2] were undertaken by the Bureau of Plant Industry, over a period of 5 years, in cooperation with a number of State agricultural experiment stations and individuals in several of the various beet-growing districts of the United States. In these tests, the home-grown variety (Morrison) ranked highest in yield of gross sugar per acre. On the part of the industry several beet-sugar companies have, from time to time, conducted tests to determine the performance of different brands of beet seed as a guide to the purchase of seed supplies for commercial plantings. From tests conducted here and abroad it was found that what was most desired by the industry, other production factors being equal, was a type of beet that would produce a high yield of sugar per acre, with quality stressed; quality in this instance referring to a high percentage of sucrose in the beet together with a high apparent purity coefficient of the juice.

It is recognized by the beet-sugar industry that in years when sugar prices are low only those types producing beets relatively high in percentage of sucrose are profitable; whereas, when prices are relatively high, the higher tonnage-yielding but somewhat lower percentage sucrose beet types may be the more profitable owing to the higher yield of sugar per acre.

The economic value of a sugar-beet type expressed in terms of profit per acre is not necessarily identical with the tonnage yield of beets per acre, nor with the percentage of sucrose in the beet, but, rather, is dependent upon all factors that make for larger sugar-per-acre yields, quality being taken into consideration. While the subject of manufacturing worth of certain sugar-beet types is not treated in this circular, it is of interest to note the results of Smolenski and Zaleski (*11*), who concluded that from the standpoint of the manufacturing worth of the sugar and tonnage types of beets to the processor, everything else being equal, the sugar type was worth approximately 20 percent more in money value than the tonnage type. In this European test the extraction of sugar from the sugar types averaged 17.2 percent, and the yield type averaged 14.9 percent. The criteria used in arriving at this conclusion were based on the results of the chemical study, which showed that the juices obtained from the sugar-type beets had, under the conditions of this test, a higher apparent purity coefficient and considerably less ash than beets of the tonnage type.

The aim of European sugar-beet seed establishments has been to produce brands of the following types: (1) High-yielding (called also tonnage or yield) type; (2) intermediate (called also normal or compromise) type; and (3) high-sucrose (or sugar) type. A common practice is to designate the brands either by distinctive name or by letters to signify the direction of breeding followed. There is no uniformity as to symbols used by the various commercial establishments. The letters "E" (Ertrag), "N" (normal), and "Z" (Zucker) are rather commonly employed to refer respectively to the three types (*8*).

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[2] Italic numbers in parentheses refer to Literature Cited, p. 27.

This circular presents a summary of 44 tests in 13 localities over a 4-year period in which the performances of these 3 sugar-beet types, as represented by several European brands, are compared. The acre-yields of sugar as calculated from the yield, sucrose percentage, and apparent purity values obtained in the tests have been chiefly used as the basis for statement as to relative efficiency, from an agronomic standpoint, of the three types in the given localities.

MATERIAL AND METHODS

Nine brands of imported sugar-beet seed, commonly used in the United States in planting much of the commercial sugar-beet acreage, were secured from carlot shipments from warehouses of the beet-sugar companies. The seed was obtained in sealed bags and in a sufficient amount to provide for a 4-year supply for conducting field tests. The several bags of seed comprising each brand were pooled and mixed thoroughly to insure a representative seed sample for each year of test. These brands were issued under code number to the agronomists cooperating in these tests. For the purpose of this investigation, which had as its object the behavior of beet types when studied over a wide range of soil types and climatic conditions, it is not believed that the names of the brands used are the important part of the study. Three of the brands used were classed by their producers as of the high-yielding type, three as intermediate, and three as high-sucrose types.[3] Since the brands used in the tests were selected to supply representatives of tonnage, intermediate, and sugar types, inclusion of certain brands, or failure to include others, has no significance; other brands of similar types would have been suitable for the experiments. Furthermore, only one lot of seed of a brand was used throughout the 4-year test period, hence any attempt to use these tests to characterize general performance of a given brand is subject to this limitation. The brands tested and their designating numbers as used in this circular are listed in table 1.

TABLE 1.—*Brands of sugar-beet seed used in the tests*

No.	Brand	Producer's classification as to type	Name of producer
1	Old Type	Yield	Zuckerfabrik Kleinwanzleben.
2	R. and G. Normal	Intermediate	Do.
3	Schreiber SKW	Yield	G. Schreiber & Sohn.
4	Schreiber SS	Intermediate	Do.
5	Dippe WI	do	Gebrüder Dippe.
6	Delitzsch E	Yield	Delitzsch.
7	Extreme Pioneer	Sugar	Zuckerfabrik Kleinwanzleben.
8	Pioneer	Intermediate to sugar	Do.
9	Delitzsch Z	Sugar	Delitzsch.

At the time the seed shipment was received, tests were made for initial germination and purity. All brands used were satisfactory and did not differ significantly among themselves in these respects. Stands as secured over the years of test indicated no noticeable drop in vitality of the seed as a result of storage.

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[3] In the text, conforming to common usage in the industry, the high-yielding type is also referred to as tonnage or yield type; the intermediate, as normal or compromise type; and high-sucrose as the sugar type

The experimental tests in the 13 localities reported in this circular were located upon a wide range of soil types and under varying climatic conditions which influenced planting, growth, and harvesting of the crop and furnished for this type of test a fairly adequate sampling of most of the major beet-growing areas in this country. The essential data for each location as to elevation, annual precipitation, supplementary water supply, and soil types are shown in table 2.

TABLE 2.—*Meteorological, supplementary water supply, and soil-type data for the 44 tests in the 13 localities, 1930–33*

State	Location	Elevation	Average annual precipitation	Supplementary water supply	Soil type
		Feet	*Inches*		
California	Davis	50	12.60	Pump irrigation	Yolo clay loam.
	Oxnard	45	13.99	do	Yolo silt loam.
	Chino	876	16.58	do	Chino silty loam.
Idaho	Castleford	3,770	7.21	Gravity	Portneuf silt loam (shallow phase).
	Twin Falls	3,770	7.21	do	Portneuf silt loam.
Utah	Sandy	4,400	11.97	do	Jordan silt loam.
Colorado	Fort Collins	5,000	14.89	do	Fort Collins light phase loam.
	Rocky Ford	4,200	10.55	do	Las Animas clay loam.
Nebraska	Scottsbluff	3,888	16.10	do	Tripp fine sandy loam.
South Dakota	Belle Fourche	2,500	12.06	do	Vale fine sandy loam.
Minnesota	Crookston	864	16.78	None	Fargo clay loam.
	Waseca	1,153	28.04	do	Carrington silty clay loam.
Michigan	East Lansing	850	28.23	do	Brookston loam.

The approximate dates of planting and thinning, percentage of stand after thinning and at harvest, and approximate dates of harvesting the sugar beets in the 13 localities are shown in table 3.

TABLE 3.—*Approximate dates of planting and of thinning, average percentage of stand after thinning and at time of harvest, and approximate dates of harvesting sugar beets of 44 tests, 1930–33*

State	Location	Range in dates of planting	Range in dates of thinning	Stand of beets after thinning	Stand of beets at time of harvest	Range in dates of harvest
				Percent	*Percent*	
California	Davis	Mar. 3	Apr. 8	92	88	Sept. 12.
	Oxnard	Feb. 11 to Apr. 10	Mar. 1 to May 10	90	84	Aug. 15 to Oct. 10.
	Chino	Jan. 28 to Mar. 10	Mar. 1 to Apr. 25	94	89	Aug. 20 to Oct. 15.
Idaho	Castleford	Mar. 10 to Apr. 19	May 1 to June 2	78	73	Oct. 13 to 30.
	Twin Falls	Mar. 14 to May 10	May 2 to June 15	95	92	Oct. 4 to Nov. 5.
Utah	Sandy	Apr. 14 to 19	June 1 to 15	101	94	Oct. 10 to 21.
Colorado	Fort Collins	Apr. 6 to May 2	May 20 to June 15	99	97	Oct. 7 to 11.
	Rocky Ford	Apr. 12 to May 7	June 5 to 10	90	78	Sept. 28 to Nov. 1.
Nebraska	Scottsbluff	Apr. 10 to 20	June 5 to 20	80	74	Oct. 5 to 25.
South Dakota	Belle Fourche	Apr. 10 to 15	June 1 to 10	82	77	Oct. 10 to 25.
Minnesota	Crookston	May 12 to 25	June 13 to 28	94	88	Sept. 13 to 16.
	Waseca	Apr. 27 to May 19	June 5 to 23	89	87	Sept. 22 to 28.
Michigan	East Lansing	May 10 to 30	June 5 to 20	88	87	Oct. 10 to 25.

The soils on which these tests were located during the 4-year period were for the most part fall-plowed, and the experimental beet crop was given the same treatment as to fertilizer application and other seasonal cultural operations as is recommended in the respective localities for the commercial sugar-beet crop. Severe outbreaks of curly top were responsible for the abandonment of the 1930 test and in a material reduction in acre yield in 1931 in the Castleford locality. No statistical difference as to resistance to this disease was found to exist among beets grown from these nine brands of seed. Leaf spot (*Cercospora beticola* Sacc.) caused some damage to the tests in Colorado, Nebraska, and Minnesota in 1932 and 1933. No apparent difference was noticed among the nine brands of seed with respect to resistance to this disease.

The experimental plot arrangement used in these tests was prevailingly of the Latin square (9 by 9) type. At Waseca and Crookston for the 4 years of test, and in East Lansing for 1930 and 1933 randomized block arrangements with 8 or 10 replicates were used. At certain stations, on account of poor stands at time of harvest, certain plots were dropped and the experiments were treated in the analysis of the data as randomized blocks with fewer replications (Rocky Ford, 1932; Davis, 1933; Sandy, 1932 and 1933). The plots were generally four rows wide (eight-row plots used in some cases) and from 60 to 75 feet in length. In the majority of the tests the rows were 20 inches apart and the beets were spaced 12 inches apart in the rows. The inner two rows of each four-row (inner six of eight-row plots) plot were harvested on a normally competitive beet basis unless otherwise noted.[4]

Determinations of sucrose and apparent purity coefficients were generally made from two or more 20-beet samples of normally competitive beets obtained from each plot. In few cases, three 10-beet samples were used. These beets were put into moisture-proof sacks and taken to the laboratory where they were washed, weighed, and analyzed.

Each beet of the sample was cut in halves, and one-half of each beet was discarded. From the halves retained, longitudinal sectors were rasped so that each beet in fair proportion to its size contributed fine pulp for the composite sample. The pulp was thoroughly mixed and used for sucrose and apparent purity coefficient determinations. One portion of this [5] composited pulp was digested by the Sachs-Le-Docte cold-water-digestion method for determination of sucrose (*2*), and frequently checked by hot-water digestion of pulp to insure accuracy of the method. The remainder of the pulp was pressed to furnish juice for Brix spindle or refractometer readings of total solids and for determination of sucrose in the juice, thus giving data from which the apparent purity coefficient could be derived. In the 1933 tests, except at East Lansing, Mich., the one solution method of Bachler (*1*) was substituted for the analysis of the juice. The data for sucrose and apparent purity coefficients indicate, therefore, the quality of the average beet grown under the experimental conditions.

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[4] As used in this circular, a normally competitive beet has competition on four sides from beets located at approximately the right distances to conform to the requirements of the test, while noncompetitive beets lack competition on one or more sides. The average weight per beet computed from the number of competitive beets in the plot multiplied by the appropriate number of beets per acre under the conditions of the test has given the yield on the basis of a 100-percent stand.

[5] The cold-water-digestion method was used at all stations except at Oxnard, Calif., where the hot-water digestion method was employed.

EXPERIMENTAL RESULTS

RESPONSES OF THE BRANDS

The constancy of behavior of the different brands of seed for the 2 or more years of test or for two relatively similar locations can be ascertained from table 4. In the statistical reduction of the data,

TABLE 4.—*Variances of yield, sucrose percentage, apparent purity coefficient, and sugar production by district or location for brands of sugar beets tested*

ACRE YIELD (TONS)

State	Locations	Years	Mean square for—				
			Brands	Brands× years	Brands× locations	Brands× years× locations	Error
		Number					
California	Oxnard and Chino	4	[1] 95.5163	[2] 17.2615	14.9770	7.2390	10.7860
Idaho	Castleford and Twin Falls	2	[1] 18.5067	2.6667	2.9736	2.9349	2.8746
Utah	Sandy	2	[1] 16.5421	1.7690			5.1425
Colorado	Fort Collins	4	[1] 6.7660	2.7388			1.9133
Do	Rocky Ford	2	[1] 11.5550	3.9634			3.6529
Nebraska and South Dakota.	Scottsbluff and Belle Fourche.	4	[1] 26.4445	4.9126	3.0526	6.7214	3.9237
Minnesota	Crookston and Waseca	4	[1] 30.3856	[1] 4.3024	3.2444	[1] 4.5499	1.9570
Michigan	East Lansing	4	[1] 10.5856	2.0258			1.4802
SUCROSE (PERCENT)							
California	Oxnard and Chino	4	[1] 4.4605	1.3562	0.7730	0.7566	0.9393
Idaho	Castleford and Twin Falls	2	[1] 1.5642	.1323	[1] .6570	[2] .3636	.1566
Utah	Sandy	2	[1] 1.2219	[1] 1.3975			.3167
Colorado	Fort Collins	4	[1] 3.1818	.2979			.2526
Do	Rocky Ford	2	[1] 2.8969	[2] .6937			.3686
Nebraska and South Dakota.	Scottsbluff and Belle Fourche.	4	[1] 3.2373	.3946	.7070	.1526	.4867
Minnesota	Crookston and Waseca	4	[1] 5.0003	.5384	.3923	.5530	.3753
Michigan	East Lansing	4	[1] 2.0255	[2] .1956			.1244
APPARENT PURITY COEFFICIENT							
Colorado	Fort Collins	4	[1] 9.9701	2.9096			2.3906
Do	Rocky Ford	2	[2] 2.0011	[2] 1.9946			.9077
Nebraska and South Dakota.	Scottsbluff and Belle Fourche.	4	[2] 5.0580	2.0412	3.2104	1.5366	2.2569
Minnesota	Crookston and Waseca	4	[2] 5.0825	3.5679	1.2249	2.8532	2.4922
GROSS SUGAR (POUNDS)							
California	Oxnard and Chino	4	[1] 4,279,535	1,433,761	1,306,877	893,664	1,129,574
Utah	Sandy	2	[2] 1,370,798	152,259			527,870
Colorado	Rocky Ford	2	[2] 736,761	353,143			298,691
Nebraska and South Dakota.	Scottsbluff and Belle Fourche.	4	[2] 942,905	361,210	387,907	[2] 649,666	389,857
Minnesota	Crookston and Waseca	4	[1] 1,607,444	[2] 272,896	158,654	[1] 325,325	174,759
Michigan	East Lansing	4	[1] 735,714	214,648			151,888
INDICATED-AVAILABLE SUGAR (POUNDS)							
California	Oxnard and Chino	4	[1] 2,875,670	885,903	1,203,777	690,197	718,439
Utah	Sandy	2	[2] 1,082,695	178,930			473,477
Colorado	Rocky Ford	2	[2] 601,809	265,353			233,964
Nebraska and South Dakota.	Scottsbluff and Belle Fourche.	4	[2] 646,563	322,261	362,182	440,685	312,165
Minnesota	Crookston and Waseca	4	[1] 1,140,209	169,809	127,009	[2] 230,705	140,206
Michigan	East Lansing	4	[1] 592,605	165,154			120,990

[1] Exceeds the 1-percent level of significance when compared with error.
[2] Exceeds the 5-percent level of significance when compared with error.

the Fisher analysis of variance method (*4*, *5*) has been followed. The results from a given location were first critically considered year by year, and such tests as were believed unreliable because of irregularity in stand or other circumstance discarded. The data for a location for each of the variables, yield of sugar beets, sucrose percentage, apparent purity coefficient, and sugar production, were analyzed, all acceptable tests being included. From this analysis, the variance attributable to brand and the interaction, brands×years, was found. Where two locations presented relatively similar conditions, the data for the two were combined, and the variances for brands and for the interactions, brands×years, brands×locations, and brands×years×locations were determined. In those cases in which, by this latter analysis, the brand performance, with respect to the attribute being considered, was significant, the interactions by districts are reported with the appropriate error. Otherwise, the results are given by location if the variance for the attribute considered was significant. The 5-percent point is taken as a convenient minimum level of significance, and indicates that differences between means as large as the observed could not occur by chance more than once in 20 trials, or, in the case of the 1-percent point, more than once in 100 trials. By fixing an appropriate standard of significance as 1 in 20 or 1 in 100, differences can be distinguished which are not attributable to errors in random sampling and which, therefore, can be taken to represent real differences in performance.

YIELD OF BEETS PER ACRE

In six of the eight comparisons made (table 4) the interactions of brands×years were not significant, indicating that in the preponderance of cases these nine brands reacted in the same way in all years of the tests. In the California and Minnesota tests, the interaction of brands×years was significant, and it is concluded that in these locations the brands reacted in a significantly differential manner in the different years. This would indicate that a single year of test may not indicate entirely the true relationships. The variance due to brands was, however, much greater than variance due to brands×years. The conclusion is, therefore, that the main differences due to brands persisted from year to year in spite of minor deviations from the general trend.

The interactions of brands×locations were not significant, indicating that the four general locations of California (Chino and Oxnard), Idaho (Castleford and Twin Falls), Nebraska and South Dakota (Scottsbluff and Belle Fourche), and Minnesota (Crookston and Waseca) responded in the same manner in one place within these general areas as in the other. Insofar as these data are concerned, results obtained at Oxnard would apply equally to Chino. The same is true for Castleford and Twin Falls, Scottsbluff and Belle Fourche, and for Crookston and Waseca.

In only one comparison was the interaction of brands×years×locations significant, indicating that these beet brands reacted in a differential manner in given localities in different years. This peculiar reaction was not duplicated in subsequent tests, as shown by the nonsignificant first-order interactions and was relatively small compared to the general differences due to sugar-beet brand.

SUCROSE

Table 4 shows the interaction between the different brands of sugar beets used and the locations where the tests were made for 2 or more years. At all locations, highly significant differences among beet brands were obtained.

In three of the eight comparisons made (table 4), an interaction was secured for brands×years, indicating that some of these brands reacted in a differential manner in different years, and that a more representative evaluation of these nine brands could be secured only through a longer period of test, this being especially true in the case of Sandy, Utah. At Rocky Ford and at East Lansing the variance for this interaction, although significant, was significantly lower than variance for brands, indicating that some beet brands were higher in percentage sucrose than others in each year of the test. At Sandy, however, the variance for interaction of brands×years was not significantly less than for brands in general, indicating that further tests should be necessary over a period of years before a valid comparison could be made of these beet brands.

The interactions between brands and locations show that aside from Castleford and Twin Falls the brands performed in essentially the same manner at the locations shown where the test was conducted at two places for 2 or more years. From the Castleford and Twin Falls tests, the significant interaction for both brands and years and brand, years, and location shows that specific recommendation as to choice of sugar-beet brand would need to be made for each place separately if European brands were to be used for commercial plantings. Under present conditions such decision is not called for, since domestically produced varieties of sugar beets resistant to curly top have completely replaced the European brands.

APPARENT PURITY COEFFICIENT

The variances of apparent purity coefficient of the juice for brand, interactions, and error in those tests in which the differences reached significant proportions, are also shown in table 4. In but one location, Rocky Ford, was the interaction of brand×years significant. This significantly differential behavior of the beet brand used in these tests is probably due largely to the prevalence of leaf spot of beets during 2 of the 3 years of the test. Since the variance due to brands did not significantly exceed the variance due to beet brands×years, it may be concluded that there was no general superiority of one commercial beet brand over another under the conditions of this test. Further tests over a period of years would be necessary if a general superiority for this attribute of one brand compared to another were to be demonstrated.

GROSS SUGAR PER ACRE

The responses of the sugar-beet brand for the locations where significant differences were obtained for the tests conducted at one or more locations for 2 or more years are shown in table 4. In only one of the six comparisons made in this table (for the tests conducted in Minnesota) was the interaction of brands×years significant. The variance for this interaction was small, however, compared with the variance due to brands, from which it is concluded that the main differences between the brands were relatively constant in spite of the significant interaction. The interaction for brands×locations×years is significant only at Scottsbluff, Belle Fourche, and at Crookston and Waseca. The differential behavior of brands×years×locations at Scottsbluff and Belle Fourche can largely be attributed to the varying degree of leaf-spot intensity and consequent damage to the beets in 2 years of the 4-year test period in these two locations.

INDICATED-AVAILABLE SUGAR PER ACRE

The variances of acre yields of indicated-available sugar for brands, interactions, and error in those tests in which the differences reached significant proportions are shown in table 4. In none of the six comparisons made in this table was the interaction of brands×years significant, indicating that the brands of seed performed in essentially the same manner in all years of the test. The same conclusion holds for the interaction of brands×locations, indicating that the main differences between the brands were relatively the same in both locations in a given area being compared, as an average of all years of the tests. In these general locations, the brands responded in essentially the same manner in one place within the general area as they did at the other, namely, Chino and Oxnard; Scottsbluff and Belle Fourche; and Crookston and Waseca. In but one comparison was the interaction of brands×years×locations significant, indicating a slight differential response in specific tests in the Crookston-Waseca districts.

The considerations outlined above give rather striking evidence that brands of sugar beets differ significantly with respect to certain attributes, and that usually a rather limited number of years of test permits reliable conclusion. Furthermore, within the limits of locations combined, it is seen that tests at one place may have rather wide applicability.

It will be noted (table 5) that in a fairly consistent way the varietal performance at one locality parallels that of distant stations. In other words, the characteristics of the respective brands persist rather definitely at the various geographic locations. With this fairly consistent behavior in mind, attempt has been made to classify the brands used in this test, on the basis of their general performance, into yield types, intermediate types, and sugar types.

In making this classification as tonnage, intermediate, or sugar type, both the differences required for significant yield and sucrose percentage have been employed, and the ranking with respect to these attributes for each year of test in each place has also been taken into consideration in determining placement. In other words, as used in this circular, the average performance of a brand with respect to the other brands and not the seed producer's label was followed. This resulted in three changes as to classification from what might have been expected from the seed producer's brand designation.

Basing judgment on performance in 44 tests, brands 1 and 3, 4 and 6, and 7 and 9 may be taken to represent, respectively, the three sugar-beet types. The average performance of these pairs is contrasted in the following discussion of type behavior at the various locations. No important change in conclusions or recommendations would have resulted if the average of brands 1, 2, and 3 had been used as average tonnage-type performance, or in the case of intermediate type, 4, 5, and 6 had been used, or, 7, 8, and 9 taken to furnish an average sugar-type behavior.

TESTS AT THE VARIOUS LOCATIONS

DAVIS, CALIF., DISTRICT, 1932–33

In 1932, the test was located in the Sutter Basin district in the Sacramento Valley. Owing to a severe infestation of the soil with *Sclerotium rolfsii*, the harvest data obtained were not considered sufficiently reliable to include in this report. In 1933, the test was located on the Yolo loam soil type on the University Farm near Davis. The date of planting, March 3, was not sufficiently early to secure the greatest contrasts in yields of sugar beets among the three groups of sugar types for this inland district, which normally has a long growing season. The data for yield, sucrose, apparent purity coefficients, and yield of gross and indicated available sugar per acre are given in table 5.

YIELD

The tonnage-type group (brands 1 and 3) significantly outyielded the intermediate-type group (brands 4 and 6) and the sugar-type group (brands 7 and 9) by 3.42 and 2.13 tons of beets per acre, respectively. These results are in conformance with those obtained for this area under large-scale commercial plantings, where the tonnage-type brands generally outyielded those of other designations.

QUALITY

The results obtained for percentage of sucrose indicate that, while large differences existed between several of the beet brands, they were of a chance occurrence. The apparent purity coefficient was highest in the tonnage-type group, being 1.80 and 1.90 greater than for the intermediate- and sugar-type groups, respectively. The differences, however, do not quite reach significance, 1.93 being required.

TABLE 5.—*Average acre-yields,[1] sucrose percentages,[2] apparent purity coefficients,[2] and acre-yields of sugar [3] obtained with nine sugar-beet brands in 44 tests (391 plots), 1930–33*

[Averages of brands 1 and 3, 4 and 6, 7 and 9 taken as representative, respectively, of tonnage, intermediate, and sugar-type performance]

State	Location	Tests	Total replicates	Performance of—												Differences required for significance	
				Brand 1	Brand 2	Brand 3	Brand 4	Brand 5	Brand 6	Brand 7	Brand 8	Brand 9	Averages of brands 1 and 3	Averages of brands 4 and 6	Averages of brands 7 and 9	Brands 1–9	Averages
								ACRE YIELD (TONS)									
		Number	*Number*														
California	Davis	1	6	19.99	15.58	19.65	15.55	15.97	17.24	16.71	19.45	18.67	19.82	16.40	17.69	[4] 2.414	1.707
	Oxnard	4	36	24.49	22.67	23.40	23.42	22.64	22.97	23.02	21.10	21.46	23.95	23.20	22.24	[4] 1.662	1.175
	Chino	4	36	25.87	24.56	25.39	24.61	23.11	23.40	22.87	23.29	21.27	25.63	24.01	22.07	[4] 1.426	1.008
Idaho	Castleford	2	18	10.27	9.61	10.45	9.85	10.57	8.96	9.41	9.44	8.37	10.36	9.41	8.89	[4] 1.156	.817
	Twin Falls	4	36	20.30	20.36	19.54	19.03	20.47	18.77	18.48	18.02	17.17	19.92	18.90	17.83	[4] 1.125	.796
Utah	Sandy	2	11	17.84	15.88	16.49	13.90	15.98	15.90	14.72	14.40	14.68	17.17	14.90	14.70	[4] 1.934	1.375
Colorado	Fort Collins	4	36	15.49	15.69	15.64	15.16	15.07	15.74	14.88	14.58	14.76	15.57	15.45	14.82	[4] .652	.461
	Rocky Ford	3	24	16.70	16.52	15.73	16.39	15.71	15.64	15.54	14.43	15.37	16.22	16.02	15.46	[4] 1.103	.780
Nebraska	Scottsbluff	4	36	19.47	18.77	19.48	18.81	17.59	18.50	18.53	17.81	17.45	19.48	18.66	17.99	[4] 1.148	.808
South Dakota	Belle Fourche	4	36	18.11	17.98	17.63	17.38	16.84	17.60	17.03	17.09	16.62	17.87	17.49	16.83	[4] .653	.462
Minnesota	Crookston	4	40	11.63	11.64	11.50	11.46	10.69	11.52	10.76	10.73	10.39	11.57	11.49	10.58	[4] .604	.427
	Waseca	4	40	17.22	17.91	17.41	16.72	16.26	16.55	16.12	15.97	15.47	17.32	16.64	15.80	[4] .647	.387
Michigan	East Lansing	4	36	14.70	14.39	14.29	14.32	13.77	13.71	13.53	13.85	12.92	14.50	14.02	13.23	[4] .574	.406
Weighted [5] average				18.00	17.54	17.63	17.19	16.82	16.99	16.62	16.33	15.87	17.82	17.09	16.24	.302	.214

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[1] Computed on basis of 100-percent stand of normally competitive beets.

[2] Determined from samples taken from normally competitive beets.

[3] Gross sugar, as shown, was obtained by multiplying computed yield of roots by sucrose percentage and averaging individual plot values, whence differing slightly from product of means given in this table; indicated available sugar was obtained individually for each plot by multiplying the gross sugar by the apparent purity coefficient as a percentage factor.

[4] Variance assignable to brand compared to variance for error exceeds 1-percent point.

[5] On basis of replication.

TABLE 5.—*Average acre-yields, sucrose percentages, apparent purity coefficients, and acre-yields of sugar obtained with nine sugar-beet brands in 44 tests (391 plots), 1930–33*—Continued

[Averages of brands 1 and 3, 4 and 6, 7 and 9 taken as representative, respectively, of tonnage, intermediate, and sugar-type performance]

State	Location	Tests	Total replicates	Performance of—												Differences required for significance	
				Brand 1	Brand 2	Brand 3	Brand 4	Brand 5	Brand 6	Brand 7	Brand 8	Brand 9	Averages of brands 1 and 3	Averages of brands 4 and 6	Averages of brands 7 and 9	Brands 1–9	Averages
								SUCROSE (PERCENT)									
		Number	*Number*														
California	Davis	1	6	18.13	18.22	17.93	17.75	18.43	18.20	17.00	17.53	18.57	18.03	17.98	17.79	1.171	0.828
	Oxnard	4	36	15.31	15.55	15.50	15.61	15.62	15.69	15.75	15.81	16.32	15.40	15.65	16.04	[6].561	.397
	Chino	4	36	15.68	15.92	15.73	15.73	16.24	16.14	16.30	16.18	16.28	15.71	15.94	16.29	[4].321	.227
Idaho	Castleford	2	18	17.60	17.87	17.62	17.86	18.33	17.63	17.87	17.74	17.89	17.61	17.75	17.88	[4].293	.207
	Twin Falls	4	36	18.17	18.56	18.37	18.64	18.75	18.55	18.96	18.83	18.97	18.27	18.60	18.97	[4].235	.166
Utah	Sandy	2	11	17.50	17.61	17.52	17.93	17.78	17.66	18.25	18.39	18.19	17.51	17.80	18.22	[4].480	.339
Colorado	Fort Collins	4	36	13.80	14.50	13.90	14.20	14.30	14.10	14.50	14.40	14.70	13.85	14.15	14.60	[4].237	.168
	Rocky Ford	3	24	15.04	15.23	15.03	15.66	15.50	15.36	15.89	15.66	16.00	15.04	15.51	15.95	[4].350	.247
Nebraska	Scottsbluff	4	36	13.94	14.31	14.00	14.58	14.42	14.40	14.82	14.42	14.74	13.97	14.49	14.78	[4].393	.278
South Dakota	Belle Fourche	4	36	15.07	15.20	15.21	15.34	15.50	15.30	15.42	15.39	15.48	15.14	15.32	15.45	[4].249	.176
Minnesota	Crookston	4	40	16.53	16.78	16.35	16.54	17.11	16.63	17.04	17.01	17.02	16.44	16.59	17.03	[4].329	.233
	Waseca	4	40	14.73	14.95	14.62	14.92	15.05	15.01	15.39	15.23	15.17	14.68	14.97	15.28	[4].203	.144
Michigan	East Lansing	4	36	16.97	17.02	16.75	17.08	17.36	17.15	17.36	17.28	17.52	16.86	17.12	17.44	[4].166	.117
Weighted [5] average				15.73	16.00	15.75	16.00	16.20	16.02	16.30	16.20	16.39	15.74	16.02	16.35	.096	.068
								APPARENT PURITY COEFFICIENTS									
California	Davis	1	6	85.20	82.30	82.20	80.60	83.90	83.20	80.90	82.50	82.70	83.70	81.90	81.80	[6] 2.730	1.930
	Oxnard	4	36	79.51	80.08	80.24	80.41	79.46	80.85	80.20	79.82	81.48	79.88	80.63	80.84	1.461	1.033
	Chino	4	36	84.03	84.64	84.88	84.32	84.31	84.76	84.40	85.06	84.42	84.46	84.54	84.41	.870	.615
Idaho	Castleford	2	18	90.71	90.04	90.81	91.61	91.11	91.14	90.31	90.36	90.74	90.76	91.38	90.53	1.117	.790
	Twin Falls	4	36	90.29	90.78	90.61	91.23	90.75	90.93	90.96	91.18	90.77	90.45	91.08	90.87	.643	.455
Utah	Sandy	2	11	92.13	92.73	92.44	92.81	92.95	93.29	93.07	92.94	92.74	92.29	93.05	92.91	1.547	1.094
Colorado	Fort Collins	4	36	88.90	89.80	88.70	89.50	89.30	89.30	90.10	90.30	89.90	88.80	89.04	90.00	[4].729	.515
	Rocky Ford	3	24	88.07	88.10	87.95	88.43	87.75	87.95	88.66	88.44	88.15	88.01	88.19	88.41	[6].550	.389
Nebraska	Scottsbluff	4	36	85.76	85.44	85.48	86.82	85.87	85.72	86.32	85.95	86.50	85.62	86.29	86.41	[6].906	.641
South Dakota	Belle Fourche	4	36	86.03	86.04	86.21	86.27	86.13	85.99	86.19	86.22	86.13	86.12	86.13	86.16	.434	.307
Minnesota	Crookston	4	40	83.57	83.38	83.72	83.52	83.18	83.66	83.89	83.92	83.78	83.65	83.59	83.84	.672	.475
	Waseca	4	40	86.68	86.31	85.99	86.44	85.98	86.64	86.84	86.64	86.73	86.34	86.54	86.79	.739	.523
Michigan	East Lansing	4	36	86.86	86.73	87.30	86.96	87.07	86.84	87.27	86.76	86.45	87.08	86.90	86.86	.605	.428
Weighted [5] average				86.27	86.35	86.36	86.63	86.30	86.56	86.67	86.65	86.67	86.32	86.57	86.17	.249	.176

GROSS SUGAR PER ACRE (POUNDS)

California	Davis	1	6	7, 214	5, 645	7, 004	5, 410	5, 802	6, 247	5, 645	6, 769	6, 900	7, 109	5, 829	6, 273	[4] 806	570
	Oxnard	4	36	7, 342	6, 935	7, 169	7, 224	6, 946	7, 121	6, 981	6, 550	6, 893	7, 256	7, 173	6, 937	531	376
	Chino	4	36	8, 016	7, 700	7, 962	7, 762	7, 501	7, 568	7, 390	7, 544	6, 957	7, 989	7, 665	7, 174	[4] 469	332
Idaho	Castleford	2	18	3, 604	3, 401	3, 673	3, 423	3, 842	3, 213	3, 345	3, 339	2, 972	3, 639	3, 318	3, 159	[4] 435	308
	Twin Falls	4	36	7, 369	7, 539	7, 172	7, 088	7, 639	6, 968	7, 001	6, 784	6, 721	7, 271	7, 028	6, 861	[4] 412	291
Utah	Sandy	2	11	6, 122	5, 486	5, 637	4, 875	5, 543	5, 467	5, 273	5, 130	5, 237	5, 880	5, 171	5, 255	[6] 620	438
Colorado	Fort Collins	4	36	4, 306	4, 551	4, 325	4, 333	4, 314	4, 443	4, 339	4, 198	4, 343	4, 316	4, 388	4, 341	201	142
	Rocky Ford	3	24	5, 071	5, 107	4, 790	5, 176	4, 932	4, 838	4, 975	4, 607	4, 950	4, 931	5, 007	4, 963	[6] 316	223
Nebraska	Scottsbluff	4	36	5, 319	5, 358	5, 310	5, 484	5, 064	5, 296	5, 493	5, 120	5, 133	5, 315	5, 390	5, 313	367	259
South Dakota	Belle Fourche	4	36	5, 436	5, 433	5, 218	5, 336	5, 200	5, 361	5, 205	5, 233	5, 109	5, 327	5, 349	5, 157	[4] 197	139
Minnesota	Crookston	4	40	3, 774	3, 875	3, 734	3, 774	3, 610	3, 805	3, 634	3, 626	3, 508	3, 754	3, 790	3, 571	[4] 177	125
	Waseca	4	40	5, 043	5, 308	5, 050	4, 979	4, 861	4, 947	4, 939	4, 851	4, 666	5, 047	4, 963	4, 803	[4] 197	139
Michigan	East Lansing	4	36	5, 033	4, 941	4, 817	4, 935	4, 834	4, 696	4, 749	4, 827	4, 556	4, 925	4, 816	4, 653	[4] 184	130
Weighted [5] average				5, 605	5, 560	5, 492	5, 473	5, 410	5, 407	5, 361	5, 258	5, 186	5, 549	5, 440	5, 274	98	69

INDICATED-AVAILABLE SUGAR PER ACRE (POUNDS)

California	Davis	1	6	6, 116	4, 652	5, 776	4, 391	4. 861	5, 201	4, 600	5, 593	5, 724	5, 946	4, 796	5, 162	[4] 715	506
	Oxnard	4	36	5, 870	5, 584	5, 811	5, 840	5, 559	5, 756	5, 615	5, 273	5, 618	5, 841	5, 798	5, 617	419	296
	Chino	4	36	6, 811	6, 550	6, 733	6, 529	6, 336	6, 396	6, 236	6, 397	5, 865	6, 772	6, 463	6, 051	[4] 379	268
Idaho	Castleford	2	18	3, 267	3, 052	3, 330	3, 093	3, 502	2, 917	3, 009	3, 020	2, 690	3, 299	3, 005	2, 850	[4] 410	290
	Twin Falls	4	36	6, 664	6, 860	6, 512	6, 488	6, 945	6, 346	6, 385	6, 214	6, 119	6, 588	6, 417	6, 252	[4] 396	280
Utah	Sandy	2	11	5, 641	5, 076	5, 195	4, 519	5, 145	5, 090	4, 909	4, 790	4, 842	5, 418	4, 805	4, 876	[6] 587	415
Colorado	Fort Collins	4	36	3, 834	4, 087	3, 833	3, 883	3, 858	3, 970	3, 912	3, 797	3, 911	3, 834	3, 927	3, 912	181	128
	Rocky Ford	3	24	4, 464	4, 494	4, 216	4, 578	4, 319	4, 205	4, 408	4, 062	4, 357	4, 340	4, 392	4, 383	[6] 279	197
Nebraska	Scottsbluff	4	36	4, 565	4, 577	4, 530	4, 769	4, 346	4, 550	4, 729	4, 407	4, 506	4, 547	4. 660	4, 618	330	234
South Dakota	Belle Fourche	4	36	4, 676	4, 672	4, 606	4, 581	4, 478	4, 609	4, 484	4, 473	4, 392	4, 641	4, 595	4, 439	[4] 172	122
Minnesota	Crookston	4	40	3, 157	3, 234	3, 133	3, 154	3, 006	3, 184	3, 051	3, 040	2, 942	3, 145	3, 169	2, 995	[4] 155	110
	Waseca	4	40	4, 368	4, 596	4, 338	4, 303	4, 178	4, 284	4, 292	4, 206	4, 048	4, 353	4, 294	4, 170	[4] 179	127
Michigan	East Lansing	4	36	4, 391	4, 303	4, 227	4, 311	4, 221	4, 093	4, 162	4, 207	3, 958	4, 309	4, 202	4, 060	[4] 164	116
Weighted [5] average				4, 836	4, 804	4, 749	4, 732	4, 672	4, 668	4, 640	4, 551	4, 495	4, 793	4, 700	4, 567	85	60

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[4] Variance assignable to brand compared to variance for error exceeds 1-percent point.
[5] On basis of replication.
[6] Variance assignable to brand compared to variance for error exceeds 5-percent point.

SUGAR PRODUCTION

In the production of gross sugar per acre the tonnage-type sugar beets outyielded the intermediate- and sugar-type groups by 1,280 and 836 pounds, respectively, 570 pounds being required for significance.

The largest production of indicated-available sugar per acre was shown by the tonnage-type group brands 1 and 3, being 1,150 and 784 pounds more than was obtained from the intermediate- and sugar-type groups, respectively, 506 pounds being required for significance. Individually, the tonnage-type brand 1 produced 1,725 pounds more indicated-available sugar per acre than brand 4, an intermediate type. However, the results are based on 1 year's experience only, and, while continuing the test over a longer period would in all probability continue to favor a tonnage-type beet, the ranking among brands might vary.

OXNARD AND CHINO, CALIF., DISTRICTS

The soil types chosen for the tests in the Oxnard and Chino districts were representative of soil types on which a major portion of the local sugar-beet acreage is located. In the Oxnard district, which lies in the fog belt, the soil is highly productive, responding more to additions of organic manures than to applications of commercial fertilizers. To supply this need, a crop of annual sweetclover (*Melilotus indica* (L.) All.), seeded in the fall of the year after beet harvest, was plowed under prior to planting the field in late April to lima beans, which, in this district, commonly precede beets in the cropping system. In the Chino district, the soil responds to moderate applications of phosphorus, the need for which was met in these tests by the application of 200 pounds per acre of 0–20–0 superphosphate drilled with the seed.

Throughout this test the beet stands were uniformly good with the exception of the Chino plots in 1931, when the stand was reduced owing to injury from sugar-beet wireworms (*Limonius californicus* Mann.). In 1931, leaf spot caused considerable damage to the beet crop in southern California, sucrose percentages of the beets being sharply reduced. No apparent differences in resistance or susceptibility to leaf spot were seen among the nine brands under test. In height of foliage, brand 1 produced the rankest growth, the foliage tending to uprightness; brand 7 produced a somewhat flat, low-spreading foliage; and brand 9 showed a noticeable lack of vigor in foliage growth. There were no pronounced visual differences in the field between the other brands under test.

YIELD

In the Oxnard tests (table 5), the tonnage-type group produced 1.71 tons more beets per acre than the sugar-type group, with 1.18 tons required for significance. At Chino, an area which lies about 90 miles inland, the tonnage-type group outyielded both the intermediate- and sugar-type groups by 1.62 and 3.56 tons of beets per acre, respectively, with 1.01 tons required for significance. Since the yield responses of the nine brands at the two places do not differ significantly, as shown in table 4, the results of these two locations are discussed together. As an average of both locations, the tonnage-type brands produced 1.18 and 2.63 tons more beets per acre, respectively, than the intermediate- and sugar-type groups.

QUALITY

At Oxnard, the beets from the sugar-type group, brands 7 and 9, had the highest average percentage sucrose, it being 0.39 [6] and 0.64 higher than in the intermediate- and tonnage-type groups, respectively, with 0.40 required for significance. The unusually low sucrose percentage in the beets for the 1931 Oxnard test is attributable to the effects of leaf spot, as previously mentioned, this percentage being lower than normal by approximately 2 percent. Downy mildew was also somewhat of a factor in this respect in 1931. In the Chino tests the sugar-type group produced an average sucrose percentage higher by 0.35 and 0.58 than the averages of intermediate- and tonnage-type groups, respectively, 0.23 being required for significance. The combined averages of the Oxnard and Chino results indicate that the highest sucrose percentage was produced by the sugar-type group, being higher by 0.37 and 0.61 percent than that of the intermediate- and tonnage-type groups, respectively. The apparent purity coefficient was not significantly different for either the Oxnard or Chino tests, or for the combined averages of these two series.

SUGAR PRODUCTION

In the production of gross sugar per acre, the largest average yield in the Oxnard tests came from the tonnage-type group; the difference, however, was not sufficiently large to equal the amount required for significance. In the Chino tests, the differences obtained were 324 and 815 pounds per acre in favor of the tonnage-type group compared with the intermediate- and sugar-type groups, respectively; 332 pounds were required for a significant difference. The combined averages of the tests from these two districts show a trend similar to that shown for tonnage yield of beets per acre. The yield of indicated-available sugar per acre follows closely the trends shown for gross sugar. This is to be expected, since no significant differences in apparent purity coefficient were obtained either in the Oxnard or Chino tests. In the combined averages of results, the tonnage-type group produced 176 and 473 pounds more indicated-available sugar (the latter a significant difference), respectively, than the intermediate- and sugar-type groups.

Under the conditions of these tests, the choice of a tonnage-type beet for maximum yields of indicated-available sugar is indicated for plantings made in California beet-growing areas for early and average dates of planting on sedimentary soils. For soils high in organic matter, the choice of seed brand would likely favor either the intermediate- or sugar-type beet.

CASTLEFORD AND TWIN FALLS, IDAHO, DISTRICTS

The variety tests in the Castleford and Twin Falls districts were located on the Portneuf silt loam (shallow phase) and Portneuf silt loam, respectively, which are representative of the area in which beets are grown. In the Castleford and Twin Falls plots, the soil was fertilized by applications of treble superphosphate at the rate of 100 pounds per acre of 0–45–0 fertilizer drilled with the seed (*10*). The soil in the Twin Falls district is generally in a higher state of fertility and the supply of irrigation water is usually more adequate than in the Castleford district, both factors having important influence upon acre yields. In addition, the Castleford district is near the breeding grounds of the beet leafhopper (*Eutettix tenellus* Bak.), a vector of the curly top virus, and as a consequence has suffered a greater reduction in beet yields from this cause than has the Twin Falls district. Because of a severe outbreak of curly top in 1930, a large percentage of the beets produced on the test plots in the Castleford district were below commercial size. In 1931, the beet yield in the Castleford plots was again depressed, being but 60 percent normal. No significant differences in resistance to this disease were shown to exist among the nine brands of seed used in these tests. In 1932 and 1933, curly top was much less of a factor in the southern Idaho area, and data from the Castleford tests for those years are reported.

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[6] Differences in sucrose percentages shown are numerical differences between average readings.

YIELD

In the Castleford and Twin Falls tests, the tonnage-type group (table 5) produced significantly greater yields of beets than the intermediate- and sugar-type groups in years when curly top was not a factor. However, when curly top reached epidemic proportions, the yields were so depressed that none of the brands used was significantly different from another, indicating that for such situations there is no alternative other than to use a curly top-resistant variety of sugar beets. This objective has actually been reached through the development of curly top-resistant varieties, and at present all of the seed used for commercial plantings in these districts is of the curly top-resistant variety.

QUALITY

There was no significant difference in the tests conducted at these two locations between the sugar- and intermediate-type groups in sucrose percentage. Both types, however, were significantly higher in sucrose percentage than the tonnage-type group when the averages for the two locations are considered together. The intermediate-type group had a slightly higher apparent purity coefficient value than the tonnage- and sugar-type groups. The differences, however, had no statistical significance and can be looked upon merely as a chance occurrence.

SUGAR PRODUCTION

In the Castleford test, the tonnage-type group produced 321 and 480 pounds more gross sugar per acre than the intermediate- and sugar-type groups, respectively; 308 pounds were required for a significant difference. In the tests at Twin Falls, the differences in favor of the tonnage-type group when compared with the intermediate- and sugar-type groups, respectively, were 243 and 410 pounds more gross sugar per acre, 291 pounds being required as a significant difference.

Similar results were obtained for yield of indicated-available sugar per acre, intermediate- and tonnage-type groups in the Castleford tests producing 294 and 449 pounds more indicated-available sugar per acre than the intermediate- and sugar-type groups, respectively, with 290 pounds as the required difference. In the Twin Falls tests, the tonnage-type group was significantly higher yielding only to the sugar-type group, the difference being 336 pounds more indicated-available sugar per acre compared to 280 pounds required for significance.

From these combined results when curly top was not a factor, the choice of either a tonnage-type or intermediate-type variety for early and medium dates of planting seems indicated for this area. As curly top-resistant varieties become available, it is possible that tonnage or intermediate types among these would similarly be indicated.

SANDY, UTAH, DISTRICT

The tests near Sandy were located on Jordan silt loam soil. The field on which the tests were conducted in 1932 and 1933 had not previously been cropped with beets, but had been used for alfalfa for several years prior to planting to potatoes in 1931. In the test with sugar beets in 1932, three replicates were discarded because of poor stand; in the 1933 test, because of wind and sandblast damage to the stand, four of the nine replications were discarded.

YIELD

The tonnage-type group (table 5) produced 2.27 and 2.47 tons more beets per acre, respectively, than the intermediate- and sugar-type groups, compared with 1.38 tons required for a significant yield difference.

QUALITY

The sugar-type group produced beets having 0.42 and 0.71 higher sucrose percentages, respectively, than the intermediate- and tonnage-type groups; a difference of 0.34 was required for significance. Differences in apparent purity coefficients failed to reach the minimum level required for significance. It is worthy of note that the apparent purity coefficients for these two tests are the highest average values recorded in the 44 tests. Collectively considered, the tests in the intermountain group, namely, those at Castleford, Twin Falls, and Sandy, are considerably above the balance of the tests in purity values.

SUGAR PRODUCTION

The tonnage-type group of brands produced 709 and 625 pounds, respectively, more gross sugar per acre than the intermediate- and sugar-type groups, compared with 438 pounds for a significant difference. In yield of indicated-available sugar per acre, the tonnage-type group averaged 613 and 542 pounds, respectively, more sugar per acre than the intermediate- and sugar-type group, a difference of 415 pounds being required for significance.

In years when curly top is not a factor, the choice of a tonnage-type beet is indicated for this area for early and medium dates of planting.

FORT COLLINS, COLO., DISTRICT

The tests at Fort Collins were located at an elevation of approximately 5,000 feet, which was the highest point for the 13 locations. The seasonal conditions during the period of tests were generally conducive to normal development of the crop. The tests were located on the Fort Collins loam, light-phase type. This soil, which is well-drained, highly productive, and easily cultivated, responded to applications of barnyard manure and phosphate bearing commercial fertilizer, both of which were supplied as needed during the 4-year period of this test. For the years 1930–32, a conversion factor of 26,136 was used to compute the competitive beet yield in terms of a 100-percent stand per acre, and in 1933 when a 10-inch spacing interval was used, a conversion factor of 31,363 was used to compute the yields to an acre basis.

YIELD

There was little choice between the tonnage-type and the intermediate-type groups (table 5), both of which were significantly higher yielding than the sugar-type group. A harvest record kept of yield of tops and root weight showed that approximately 9 tons of beet tops were obtained from an average harvested crop of 15 tons of beets per acre and that the tonnage-type group produced about 0.50 ton more tops per acre than the sugar-type group, with a difference of 0.29 ton of tops being required for significance.

QUALITY

The highest average percentage of sucrose was obtained from the sugar-type group, this being 0.45 and 0.75 greater, respectively, than in the intermediate- and tonnage-type groups, with a difference of 0.17 being required for significance. In respect to the apparent purity coefficient, the sugar-type group exceeded the intermediate- and tonnage-type group by 0.96 and 1.20, as compared with 0.52 required for significance.

SUGAR PRODUCTION

In pounds of gross sugar per acre the small differences obtained among the three groups in tonnage yield were offset by differences in sucrose percentages, so that there was a balancing effect in yield of gross sugar per acre, with the result that no significant difference was obtained among the three groups in this respect. In yield of indicated-available sugar per acre, the trend of results is similar to that shown for yield of gross sugar. The intermediate-type group produced the highest, though not significantly greater yield of indicated available sugar.

ROCKY FORD, COLO., DISTRICT

The tests near Rocky Ford were located on the Rocky Ford silt loam and Las Animas clay-loam soil types. The soil types selected are typical of the area, for high production, and respond to moderate applications of commercial fertilizer and barnyard manure. Treble superphosphate drilled with the seed was used at the rate of 100 pounds per acre. This area is subject to frequent outbreaks of leaf spot. In years when the disease reaches epidemic proportions, the partial or total destruction of the foliage of the beet plants one or more times during the growing season brings about serious reduction in yield or quality, or both, of the crop (*3*, *9*). During the period of test, mild outbreaks of leaf spot were experienced in 1932 and 1933. None of the nine brands used in these trials was resistant to this disease.

The plot arrangement conformed to a 9 by 9 Latin square, the tests being harvested on that basis except as noted for 1932 when flood injury to three series of replications necessitated discarding them, and the trial was considered as a six-times-replicated, randomized-block test.

YIELD

Differences in yield (table 5) between the three groups were relatively small. The highest average yields of roots were harvested from the tonnage-type group which produced 0.20 and 0.76 ton more beets per acre than the intermediate- and sugar-type groups, respectively, with a difference of 0.78 ton required for significance. A study on the yield of beet tops, similar to the one conducted at Fort Collins, was made from the various groups in 1933. The yields of tops were 0.86 and 1.47 tons, respectively, higher for the tonnage-type group than for the intermediate- and sugar-type groups, a difference of 0.77 ton being required for significance.

Previous experience in this area indicated that the commercial beet types that did not produce an excessively large proportion of foliage to root weight were, if quality was taken into consideration, apparently more efficient producers of sugar than those varieties that produced a large foliage growth (*9*).

QUALITY

The highest average percentage of sucrose in the beet was obtained from the sugar-type group, which produced beets having 0.44 and 0.91 higher sucrose percentages than the intermediate and tonnage types, respectively, with 0.25 required for significance. These differences are among the high ones found for the 13 locations. The sugar-type group had the highest average apparent purity coefficient, being 0.22 and 0.40 higher than the intermediate- and tonnage-type groups, respectively, with 0.39 required for a significant difference.

SUGAR PRODUCTION

In yields of gross and indicated-available sugar per acre, there are no significant differences between the three groups, all being of approximately the same level. Under the conditions of this test and in years when leaf spot is not a factor, the use of either an intermediate or sugar type seems indicated for this district.

SCOTTSBLUFF, NEBR., AND BELLE FOURCHE, S. DAK., DISTRICTS [7]

The variety tests at Scottsbluff were located on the Tripp fine sandy-loam soil that is easily cultivated and adapted to the growing of a wide variety of crops. The tests at Belle Fourche were located on the Vale fine sandy soil, which is generally representative of the soil type on which much of the sugar-beet acreage in this district is located. The beet stands during the period of test were satisfactory except in those years when wind and the damping-off diseases reduced initial stands somewhat. Leaf spot, which was severe in 1932 and 1933, depressed the percentage of sucrose in the beet.

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[7] The data for tests at Scottsbluff, Nebr., and Belle Fourche, S. Dak., were contributed by S. B. Nuckols.

YIELD

In the Scottsbluff tests (table 5), the tonnage-type group produced 0.82 and 1.49 tons more beets per acre than the intermediate and sugar types, respectively, with a difference of 0.81 ton required for significance. In the Belle Fourche tests the range was somewhat narrower, the tonnage-type group outyielding the intermediate- and sugar-type groups 0.38 and 1.04 tons per acre, respectively, with a required difference of 0.46 ton. The tonnage yield responses at Scottsbluff and Belle Fourche can be discussed advantageously together, since the behavior of the plants was not significantly different in these two locations. As an average of both localities, the acre-yield increase of the tonnage types over the intermediate and sugar types was 0.60 and 1.27 tons more beets, respectively.

QUALITY

The sugar-type group in the Scottsbluff test produced 0.29 and 0.81 higher sucrose percentages in the beet, respectively, than the intermediate and tonnage types, with a difference of 0.28 required for significance. In the Belle Fourche test the differences were only 0.13 and 0.31 in favor of the sugar-type group compared with the intermediate- and tonnage-type groups, respectively, a difference of 0.18 being required for significance. With respect to the apparent purity coefficient, the test at Scottsbluff indicates that the sugar-type group averaged 0.12 and 0.79 higher purity than the intermediate and tonnage types, respectively, with an average difference of 0.64 required for significance. In the Belle Fourche test the readings were approximately of the same magnitude, and no significant difference was obtained.

SUGAR PRODUCTION

The yields of gross sugar per acre were of approximately the same level in the Scottsbluff test with a slight but not significantly different trend in favor of the intermediate-type group. In the Belle Fourche tests the intermediate-type group produced 192 pounds more gross sugar than the sugar-type group, with a required difference of 139 pounds.

In yield of indicated-available sugar again there was no significant difference between the three groups in the Scottsbluff test. In the Belle Fourche tests the tonnage-type group produced 202 pounds more sugar per acre than the sugar-type group, with 122 pounds required for a significant difference. Under the conditions of these tests, when leaf spot is not a factor, the choice of either a tonnage- or intermediate-type brand seems indicated for early and medium dates of planting.

NORTHERN AND SOUTHEASTERN MINNESOTA DISTRICTS

The tests in the northern Minnesota district were conducted near Crookston in the Red River Valley on the Fargo clay loam, a soil type on which a majority of the beets in this district were grown.

These soils usually show response to phosphate applications, and in these tests, 120 pounds of 0–16–0 fertilizer were drilled with the seed. In the southeastern Minnesota district, the tests were located on the experimental fields of the southeastern branch of the Minnesota Agricultural Experiment Station near Waseca on Carrington silty clay loam. This soil was frequently manured and in addition had residues of the preceding stubble crop from soybeans plowed under. In the Crookston tests, lack of sufficient moisture during the growing period was responsible for depressing the yields in 2 years out of 4. In the Waseca tests, the conditions for crop growth were more favorable, and this was reflected in increased tonnage yield.

YIELD

In the Crookston tests, the tonnage-type group (table 5) yielded 0.99 ton more beets per acre than the sugar-type group, with 0.43 ton required for significance. At Waseca, the margin in favor of the tonnage type was considerably increased, being 0.68 and 1.52 tons greater than for the intermediate- and sugar-type groups, respectively, with 0.39 ton required for significance. Combining the average results for both places, the tonnage-type group outyielded the intermediate- and sugar-type groups by 0.38 and 1.25 tons of beets per acre, respectively, 0.29 ton representing the value required for significance when the two locations are considered together.

QUALITY

In the Crookston tests the sugar-type group produced beets having 0.44 and 0.59 higher sucrose percentages than the intermediate- and tonnage-type beets, respectively, 0.23 being required for significance. In the Waseca tests differences were 0.31 and 0.60 in favor of the sugar-type group, compared with intermediate and tonnage types, respectively, with 0.14 required for significance. The average results from both places showed that the sugar-type group produced sucrose percentages higher by 0.38 and 0.60 than the intermediate- and tonnage-type groups, respectively, a difference of 0.13 being required for significance. In the apparent purity coefficients there was no significant difference among the three groups either at Crookston or at Waseca.

SUGAR PRODUCTION

In the Crookston tests the acre yield of gross sugar was 219 and 36 pounds greater in the intermediate-type group than in the sugar- and tonnage-type groups, respectively, with 125 pounds required for a significant difference. In the Waseca tests the tonnage-type group produced 84 and 244 pounds more gross sugar per acre than the intermediate- and sugar-type groups, respectively, with 139 pounds as the indicated amount for a significant difference. The average gross sugar yields of the two locations showed that the tonnage-type group had a significantly higher yield than the sugar-type group, this being 214 pounds compared with the difference of 94 pounds required for significance.

Considering the Crookston tests, in yield of pounds of indicated-available sugar per acre, the intermediate type produced 174 pounds more indicated-available sugar than the sugar-type group with 110 pounds required for a significant difference. In the Waseca tests, the tonnage-type group outyielded the sugar-type group 183 pounds indicated-available sugar with 127 pounds as the indicated difference required for significance. Combining the average performances of the groups at the two locations, the tonnage-type group outyielded the sugar-type group 166 pounds compared to 86 pounds required for a significant difference. Similarly the intermediate-type group outyielded the sugar-type group by 149 pounds, but did not differ significantly from the tonnage-type group. From these tests, it would appear that the choice of a tonnage or intermediate type for early and intermediate dates of planting is indicated.

EAST LANSING, MICH., DISTRICT

The East Lansing tests were located on the Brookston loam soil type on the Michigan State College agronomy farm. The fertilizer requirements were met by an application of commercial fertilizer at the rate of 300 pounds per acre of a 4–12–4 mixture. During the 4-year period of test, a series of dry years prevailed, which resulted in an accumulated deficiency of 3 inches moisture per year. This condition is reflected in a somewhat low acre yield.

YIELD

The tonnage-type group (table 5) produced 0.48 and 1.27 tons more beets per acre than the intermediate- and sugar-type groups, respectively, with 0.41 ton required as a significant yield difference.

QUALITY

The sugar-type group produced beets having 0.32 and 0.58 higher sucrose percentages than those produced in beets of the intermediate- and tonnage-type groups, respectively, 0.12 being found as the required difference necessary for significance. There was no significant difference among the three groups in the apparent purity coefficients, all of the values being of approximately the same level.

SUGAR PRODUCTION

In yield of gross sugar per acre the tonnage-type group produced 109 and 272 pounds more gross sugar to the acre than was obtained from the intermediate- and sugar-type groups, respectively, compared with a difference of 130 pounds required for significance. A similar trend was noted in the yield of indicated-available sugar, this being 107 and 249 pounds in favor of the tonnage-type group compared with the intermediate- and sugar-type groups, respectively, with an indicated difference of 116 pounds required for significance. From the results of these tests, choice of a tonnage or an intermediate-type for early and medium dates of planting is indicated.

The result of a series of comparison tests conducted at East Lansing in 1927–29 (*6*) with a large number of beet types conforming to the three group designations was very similar to the results obtained from this present, more intensive comparison study during a 4-year period. Therefore, further confirmation is given relative to the nine brands of seed used in the tests reported herein as representing a reasonably fair cross section of the tonnage-, intermediate-, and sugar-type groups.

DISCUSSION

YIELD

The preponderance of data obtained with the brands of seed used in this study indicates that, from the viewpoint of acre yield, preference should be given to the tonnage-type or intermediate-type beet in most districts with early to medium dates of planting. For districts where disease situations frequently occur, the use of varieties resistant to these diseases is necessary for satisfactory results. The general trend of results indicates that, unless disease conditions are more serious in one locality than in another, tests conducted at one location within the State, when the test is properly planned and adequately replicated, should have rather wide applicability.

The average computed tonnage yields of sugar beets per acre for all tests are given in table 5. From this summary, it is seen that according to the z test (*4*) the differences in acre yields found among the beets produced from the various brands exceeded the 1-percent level of significance, indicating that the differences obtained were due to brands of seed used and were not the result of chance occurrence. The tonnage-type brand of seed performed, in general, true to its type designation, brand No. 1 being highest in average yield. Brands 1 and 3, taken as representative of the tonnage type, significantly outyielded brands 4 and 6 and 7 and 9, intermediate and sugar types, respectively, by 0.73 ton and 1.58 tons of beets per acre, 0.21 ton being required for significance. From this it may be concluded that, under the conditions of these tests, the brands designated as tonnage, intermediate, and sugar types performed in most locations according to their respective type designation. The behavior of the types in yields at each location is shown graphically in figure 1.

QUALITY

The percentage of sucrose and the apparent purity coefficient of the beet are of utmost importance to the processor, since the ability to pay the maximum amount for a ton of beets depends not only on the selling price of sugar, but also upon the amount of sugar recovered from each ton of beets. As noted in the introductory paragraphs, Smolenski and Zaleski (*11*) found that under the conditions of the tests in Poland there was a greater marketable sugar yield per ton of beets from the sugar type than from the tonnage type. Pazler (*7*), in working with nine beet brands of tonnage-, intermediate-, and sugar-type designations in five localities in Czechoslovakia, stated that not only is it necessary to consider the percentage of sucrose in the beet but also its coefficient of purity. Commenting on the apparent purity coefficient, he concluded that composition of sugar-beet juices is often influenced more by the locality where the test is conducted than by the variety itself. There are localities in the United States where the apparent purity coefficient for a given percentage of sucrose in the beet is higher than in other localities, resulting in a higher average extraction of sugar from a ton of beets processed. Obviously, for the beet-growing areas in general, the problem of finding varieties or brands producing the largest quantity of sugar per ton of beets processed is of significant importance, hence the maintenance of a quality so that high extraction is not sacrificed must not be overlooked.

SUCROSE

The average percentage of sucrose in the beet is given in table 5. The highest average percentage is shown from brands 7 and 9, designated as sugar-type brands. In spite of the fact that the sugar-type group produced consistently higher sucrose values than the intermediate- and tonnage-type averages, the differences in sucrose percentages, while highly significant, were only 0.33 and 0.61, respectively, 0.068 required for significance. These average differences are much smaller than those reported by Smolenski and Zaleski (*11*), who, from the results of tests conducted in Poland during a 3-year period, found an average difference of 2.08 higher sucrose in the sugar-type beet than in the tonnage-type beet. The differences found conform closely to those reported for Germany by Roemer (*8*).

The behavior of the types as to sucrose percentage at each location is shown graphically in figure 2.

The average values of apparent purity coefficients are given in table 5. Of interest are the prevailing high purity values for the intermountain areas—Castleford and Twin Falls, Idaho, and Sandy, Utah—where in no case was a value less than 90 obtained. Collectively considered, the intermediate-type group averaged 0.25 and 0.40 higher in apparent purity coefficient than the tonnage- and sugar-type groups, respectively, with a difference of 0.176 required for significance. Collectively considered, however, the differences between the three groups are small for all locations considered, which is not surprising when viewed in the light of the small average differences shown to exist between these nine brands in percentage of sucrose in the beet. The results indicate that, when differences in purity do not exceed those found among these nine brands, many more beets apparently are required for an adequate sampling of the sugar-beet population to evaluate critically the apparent purity coefficients than are required for the determination of sucrose percentages in the beet.

SUGAR PRODUCTION

Tests made in Europe with tonnage-, intermediate-, and sugar-type brands of sugar-beet seed have indicated that these brands generally performed according to type designation. However, in many of these tests the divergences among the types in both root yields and sucrose percentages have been much greater than those shown for the averages of tests reported herein, in which the tonnage-type group produced on an average 1.58 tons more beets, or about 10 percent greater yield of roots than that shown for the sugar-type group. This is considerably less than the 30-percent difference in yielding ability of the tonnage-type brands claimed by some seed firms. In percentage of sucrose in the beet the average difference for the sugar-type group was shown to be but 0.61 higher than that for the tonnage-type group compared with a difference of 1.5 or more between the higher sugar and tonnage types said to be obtainable in certain localities in Europe. Obviously, the narrow range in the differences obtained from the brands of seed used in these tests is of interest to the industry. It strongly indicates that while the European brands did perform according to type designation under the widespread conditions of these tests, they did not duplicate the wide differences reported when these brands were grown in the environment where they were bred.

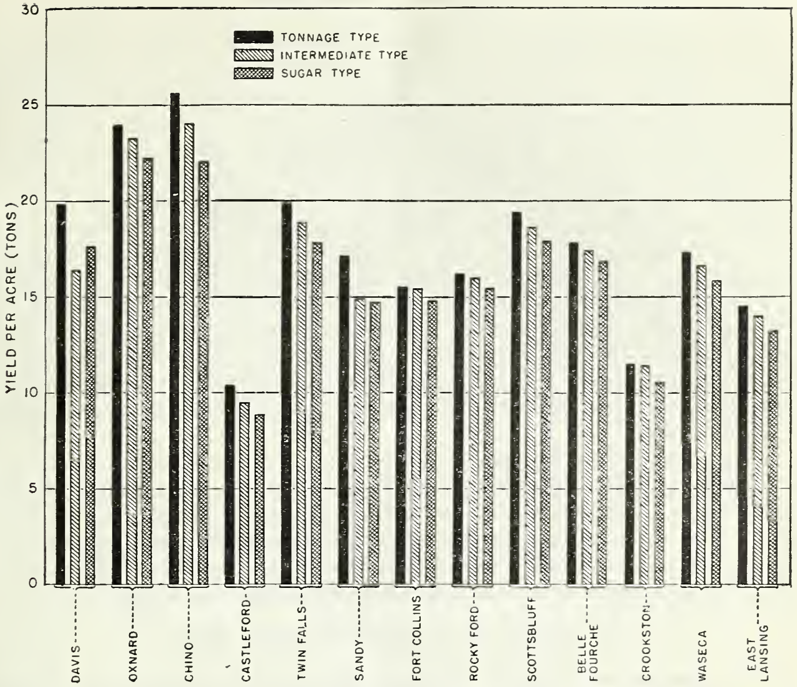

FIGURE 1.—Average acre yield of sugar beets from the tonnage-, intermediate-, and sugar-type groups at 13 locations, 1930–33.

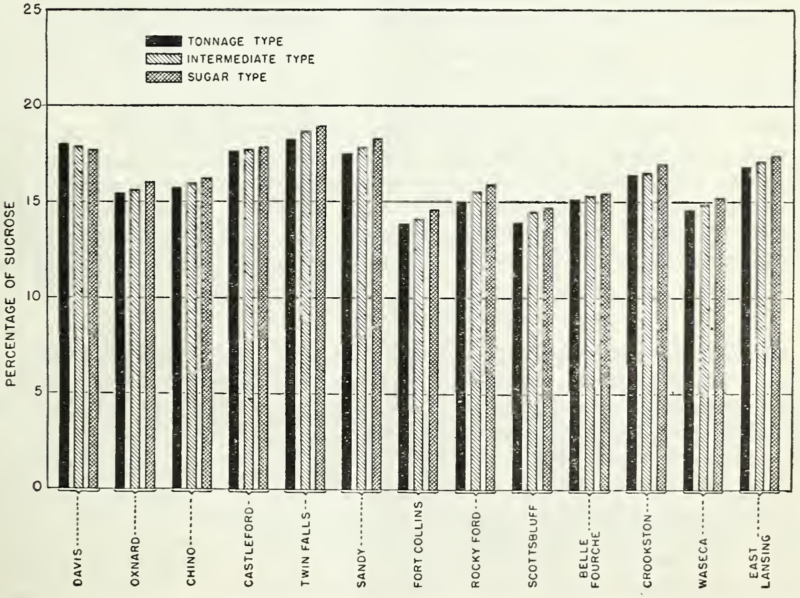

FIGURE 2.—Average sucrose percentage in sugar beets grown from the tonnage-, intermediate-, and sugar-type groups, at 13 locations, in the tests 1930–33.

GROSS SUGAR PER ACRE

The average yields of gross sugar reported in pounds per acre are shown in table 5. In 8 of the 13 locations the variances assignable to brand response exceeded the 1-percent point, and at 2 others the 5-percent level required for significance was exceeded. Since the gross sugar yield is obtained by multiplying the tonnage yields of beets per acre by the percentage of sucrose, it follows that the combined effects of root yields and sucrose percentages with the different types were sufficiently great that, at 10 locations, differences were found exceeding the level of significance chosen to exclude chance occurrence. At the three remaining locations, the results were not significant, indicating that there was a balancing effect between tonnages of roots produced and the percentage of sucrose in the beet. The tonnage-type group, as a grand average, produced 109 and 275 pounds more gross sugar per acre than were produced from the intermediate- and sugar-type groups, respectively, with 69 pounds required for significance.

The average results of these tests are in harmony with those reported by Soucek (*12*) for a series of sugar-beet-type trials conducted in eight localities in Czechoslovakia, with nine brands of seed, in which the yield types of beets produced the largest acre yields of sugar, the intermediate types were next, and the sugar types the lowest, but, as has been brought out, the actual quantity differences are small.

INDICATED-AVAILABLE SUGAR PER ACRE

The average acre yields of indicated-available sugar are given in table 5. The same statement made for gross sugar for the different locations applies to acre yields of indicated-available sugar. The tonnage-type group produced as an average of the 44 tests 93 and 226 pounds more indicated-available sugar per acre than the intermediate- and sugar-type groups, respectively, 60 pounds being required for a significant difference. At the three locations where significant differences were not obtained, the balancing effect of differences in tonnage yields, percentage of sucrose, and the apparent purity coefficient are indicated. This is borne out by examination of the data which tend to show a decrease in percentage of sucrose and apparent purity coefficients as the acre yields of roots increase sufficiently to bring the average computed yields of indicated-available sugar per acre at these locations to approximately the same level.

SUMMARY

Intensive agronomic tests were conducted during the period 1930–33 with nine brands of sugar-beet seed representing tonnage, intermediate, and sugar types of beets. The tests were made in 13 locations, which represented a wide range in field conditions, in California, Idaho, Utah, Colorado, Nebraska, South Dakota, Minnesota, and Michigan. During the 4-year period, 44 tests were made, involving 391 plots of each brand of seed, or a total of 3,519 plots for the entire study. The tests were located on a number of widely different soil types and represent a fair cross section of the types on which a considerable portion of the commercial sugar-beet crop in these respective districts is grown.

In 10 of the 13 districts significant differential responses for acre yields of sugar as calculated from the factors, acre yields of roots, sucrose percentages, and apparent purity coefficients, were found among the brands used. When the brands are classified on the basis of their general performance as tonnage, intermediate, or sugar type, it was found that in sugar production the tonnage type exceeded significantly the other two types at Davis and Chino, Calif., Castleford, Idaho, and Sandy, Utah. It also exceeded the sugar type significantly in sugar production at Twin Falls, Idaho, Belle Fourche, S. Dak., Crookston and Waseca, Minn., and East Lansing, Mich. No significant differences were found at these places between the tonnage and intermediate types. At Oxnard, Calif., Fort Collins and Rocky Ford, Colo., and Scottsbluff, Nebr., no significant differences were found among the three types. There is clearly a strong tendency at all but the four last-named places for those types which produce greater root yields to show greater sugar production. This comes about because their superiority in root yield over the sugar type more than compensates for their slightly lower quality.

Sugar production by the sugar beet is, therefore, not only influenced by the factors of soil, moisture, and climate, and by the prevalence or absence of insect pests and diseases but may also be affected to a considerable degree by the differential responses of sugar-beet brands to the wide range in altitude and latitude in the irrigated and humid areas where the crop is commercially grown. The tests have sought to sample as adequately as possible a wide range of conditions and to furnish indications for the guidance of the industry and plant breeder as to sugar-beet type most suitable for a given district.

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